Unit 4: The Immune System and Blood Stem Cell Lineage Tree

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California State Standards

Biology/Life sciences
10.b. Students know the role of antibodies in the body's response to infection. *"Cells produce antibodies to oppose antigens, substances that are foreign to the body." "Antibodies can inactivate pathogens directly or signal immune cells that pathogens are present."*
10.e. Students know why an individual with a compromised immune system (for example, a person with AIDS) may be unable to fight off and survive infections by microorganisms that are usually benign.
10.f. Students know the role of phagocytes, B-lymphocytes, and T-lymphocytes in the immune system. *"Phagocytes move, amoeba-like, through the circulatory system, consuming waste and foreign material, such as aged or damaged blood cells and some infectious bacteria and viruses. Two broad types of lymphocytes (a class of white blood cells) originate in the bone marrow during embryonic life."*

Investigation and Experimentation
1.l. Analyze situations and solve problems that require combining and applying concepts from more than one area of science.

Goals

- Understand the basics of the immune system and its development through hematopoietic (blood-forming) stem cells.
- Distinguish between different disorders (leukemia, lymphoma, sickle cell anemia, and HIV/AIDS).
- Recognize various treatment options for patients with diseases, specifically bone marrow transplants.

Objectives

1. Students will be able to outline the organization of the immune system and hematopoietic stem cell lineage tree.
2. Students will be able to define the types of lymphoid cells and myeloid cells and describe their general functions.
3. Students will be able to explain the relationship between components of the immune system, such as antigens and antibodies.
4. Students will be able to recognize symptoms, understand the causes, and identify the cells involved in various immune system responses.
5. Students will be able to describe the process of, need for, and risks associated with bone marrow transplants.

UNIT OUTLINE

I. Invitation

Depending on familiarity with microscopes and previous units, choose one or more of these activities to begin this module. PowerPoint presentation for this section: Stem Cells and the Immune System.

A. Human blood observation

Download or print human blood images (present PowerPoint slides from American Society of Hematology (ASH) or browse images from the ASH image bank)

OR

Purchase human blood smear slides and view through light microscopes (blood smear slides: basic or browse entire selection)
If viewing slides, use Appendix A: Human blood observation

When observing images or viewing samples of human blood, answer the following questions.
a. How many different types of cells do you see?
b. What do you think each type of those cells (identified by shape and/or color) does in the body?

Discuss as a class:
a. What is the role of blood?
b. Why do you think there are different types of blood cells?

B. Feeling sick? Think, Pair, Share.

Answer the questions below, and then discuss with a partner. Finally, share with the class.
a. Think about last time you were sick. How did you know you were sick? What did you feel like? (What were your symptoms?)
b. How did you make yourself feel better?
c. What do you think caused you to feel this way?
d. What do you think is going on in your body when you are sick? How does your body respond?

C. The "Cell is Right" activity:

1. Learn about the hematopoietic stem cell lineage tree.
Appendix B: Teacher guide with student handouts
a. Print large pictures of each type of cell that students will cut out and place up on the board. Each picture includes cell functions.
b. Draw a blackboard diagram (outline of lineage "tree") partially filled out with information.
c. Play! “Price is right” game show style; students read functions and tape “leaves” (cell cut-outs) on correct spots in the "tree."

AP student expansion/discussion questions:
a. Are T cells a type of stem cell? Are they more like a progenitor cell?
b. What is the difference between a stem cell, a progenitor cell, and a mature cell type?

II. Exploration

A. Lecture: Body Basics - The Immune System

1. Use lecture outline below and refer to Teacher Background Information for content expansion.
a. Brainstorm and clarify causes of disease and compare with injury: pathogens, genetics, environment, etc.
b. What is the body's response to disease and injury? Basic organization of immune system:

- Nonspecific response (innate immunity)
- Skin, mucous membranes, secretions
- Myeloid leukocytes (including all phagocytic cells), proteins, inflammatory response, mast cells
- Specific response and antigen-antibody relationship (acquired immunity)
- Lymphocytes (B, T and plasma cells)

c. Lymphocyte development: use lineage tree on board to refer to different cell types

- Origination in bone marrow
- Unlimited supply of hematopoietic stem cells
- Asymmetric cell division (one daughter stays in bone marrow)
- Note: *myeloid lineage begins and released from here*
- Differentiation into lymphoid stem cells in the bone marrow
- General B cells mature in the bone marrow
- Differentiation into lymphoid stem cells in the thymus
- General T cells mature in the thymus
- Migration of mature general B and T cells
- Secondary lymphoid organs: lymph nodes, spleen, tonsils, external body surfaces (intestinal, respiratory, urinary, reproductive)

d. Immune activation and response

- What triggers these cells to respond?
- Antigen-antibody binding
- Structure, location and function (tag and disable antigens, alert T cells, macrophages, leukocytes of presence of antigens) of

antibodies
- B cells recognize antigens, proliferate, and produce specific antibodies.
- B cells differentiate into plasma cells to produce more antibodies
- B cells differentiate into memory cells, held in supply for activation from second encounter by same antigen
- T cells recognize and destroy tagged antigens and proliferate
- Cytotoxic T cells bind to antigen on plasma membrane of target cells and directly destroy the cells
- Helper T cells activate B cells, cytotoxic T cells, natural killer cells and macrophages and "help" them respond to primary infection
- Remaining cells can respond to secondary exposure

e. Use supplemental homework/guided lecture notes worksheet
Appendix C: Lecture review notes

2. Natural Killer Cells (NKCs); where do they fit in? PowerPoint presentation and activity:

a. Note placement of NKCs in the tree. Explain role of NKCs from background information resource, above.

- NKCs make up 10-15% of the circulating lymphocytes in the adult.
- Exact physiological roles are unclear; they may be able to recognize and destroy cancer cells and cells infected with certain kinds of viruses.
- They do not use the same gene rearrangement mechanism as other lymphocytes (they seem to be more primitive WBCs).
- When other lymphocytes are prevented from developing in experimental mice, NKCs take over the job of the other WBCs.

b. In groups, students decide if NKCs should be considered a part of nonspecific or specific immunity.

- Use the following reading to make a decision: Natural Killer Cell article.
- Can also make this a web quest in-class or homework assignment so groups can come up with evidence.

c. Each group makes a claim and gives evidence for and against their conclusion in an oral presentation.

- "NK cells are sometimes considered to be one of the innate immunity mechanisms, because it is unclear how or whether these cells develop responses to specific stimuli." (Dee, Puleo, Bizios, 2002)

Images that can accompany lecture:
Stem cell lineage tree - condensed
Stem cell lineage tree - expanded
Types of blood cells
Lymphatic system

III. Application

A. Challenging the Immune System: diagnosis and understanding

Students encounter a personal perspective as they learn about blood disorders through the eyes of patients using one of four case studies:
Appendix D case studies: leukemia, lymphoma, sickle cell anemia, HIV/AIDS
1. In groups of four, students take on the case of a patient having one of the following disorders: leukemia, lymphoma, sickle cell disease and HIV/AIDS.
2. Read case study and answer questions in groups. Finish for homework if students need more time or need to use the internet for gathering more information.
3. Next day: students meet in jigsaw teaching groups and then explain their cases to groups (here, students are playing the doctor role.) Students fill out the following worksheet as they learn about each disease in their teaching groups.
Appendix E: Blood Disorder Summary Table - includes student worksheet and teacher version

B. Bone marrow transplants: After learning about various disorders, students explore the option of bone marrow transplantation and compare it to other forms of treatment.

1. Watch Animation/Tutorials:
Bone Marrow Transplant animation AND Bone Marrow or Stem Cell Transplants
2. Answer these questions

- What are the patient's options?
- What is a bone marrow transplant? How does it work? What critical cells are needed? Refer back to cell lineage tree.
- What are the dangers of bone marrow transplants? (Immune rejection and Graft Versus Host Disease)
- Compare tissue typing (HLA) to blood typing.

3. Extensions/homework activities
a. After completing case studies, have students Jigsaw or read as homework these "Science Daily" articles:
Leukemia patients survive with stem cell transplant
Exploring gene therapy to fight AIDS
Bone marrow transplant can cure sickle cell disease
Why is non-Hodgkin's Lymphoma so rare?
Umbilical cord transplants

OR
b. Talk with students about the various careers related to this unit, like an Immunologist.

IV. Assessment

A. Students browse normal, leukemic, and sickle cell blood smear samples and sketch/compare differences in cell morphology between the samples. Carolina: Visualizing Blood Microscope Slide/Poster Set.

B. Teacher designs questions to test understanding of lecture topics and concepts behind each disease.

C. Turn in Blood Disorder Summary Table from case study activity.

ADDITIONAL RESOURCES:
National Cancer Institute Visuals Online

Blood Cancers
American Cancer Society
Leukemia and Lymphoma Society

Sickle Cell Anemia
National Human Genome Research Institute: Sickle Cell Anemia

HIV/AIDS
National Institutes of Health: AIDSinfo
National Institutes of Health: MedlinePlus
